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Staff Summary Report of the Colombia - U.S. Study Panel on
THE POTENTIAL FOR GRADUATE EDUCATION AND RESEARCH
IN ENGINEERING, PHYSICS, AND APPLIED GEOLOGY IN COLOMBIA

Bogotá, Colombia

14 - 25 February 1972

Jointly Sponsored by the
Colombian Fund for Scientific Research and Special Projects
"Francisco José de Caldas,"
The Colombian Institute for the Development of Higher Education
and the National Planning Department
Colombia

and

The National Academy of Sciences
United States of America

This report, submitted to the Agency for International Development under contract AID/csd-2584, Task Order 5, is based on a translation of an original Spanish document, the "General Report" prepared by participants in the Colombia - U.S. Study on the Potential for Graduate Education and Research in Engineering, Physics, and Applied Geology in Colombia. The meetings took place in Bogotá, 21 - 25 February 1972, under joint auspices of the Board on Science and Technology for International Development, Office of the Foreign Secretary of the U.S. National Academy of Sciences, the Colombian Fund for Scientific Research and Special Projects "Francisco José de Caldas" (COLCIENCIAS), the Colombian Fund for the Development of Higher Education, and the National Department of Planning of Colombia.

The "General Report" contains the important issues and policy questions common to six engineering areas and to those aspects of geology and physics examined, as well as the joint panel's conclusions and recommendations.

The six detailed working group reports are to be issued by COLCIENCIAS in a full proceedings in Spanish.

PREFACE

The Colombia - U.S. Study Panel on the Potential for Graduate Education and Research in Engineering, Physics, and Applied Geology in Colombia is a part of a continuing collaborative effort of the U.S. National Academy of Sciences (NAS) and three Colombian institutions-- the Colombian Fund for Scientific Research and Special Projects "Francisco José de Caldas" (COLCIENCIAS), the Colombian Institute for the Development of Higher Education (ICFES), and the National Department of Planning (DNP).

In 1968, the Colombia - U.S. Workshop on Science and Technology in Development stimulated discussions on applying the scientific and technological resources of Colombia to improving the welfare of its people. In this regard, a recommendation to create a fund for scientific research under the authority of the Ministry of Education was particularly significant. Another recommendation concerned with human resources called for assessing the need for graduate education and research in Colombia in relation to future development needs. It is in this context that COLCIENCIAS, ICFES, DNP, and NAS have been examining the potential for graduate education and research in Colombian universities in biology, chemistry, engineering, applied geology, mathematics, and physics. NAS participation in the studies is funded by the Agency for International Development (AID) Mission in Colombia; local expenses are provided by COLCIENCIAS and ICFES.

The methodology for the studies and an executive committee to oversee them was established by officials of the four co-sponsoring organizations during a meeting in Washington, D.C., March, 1970. The studies in chemistry and mathematics were carried out in February and April, 1971, respectively.

After a 5-month delay caused by the closing of Colombian universities, the executive committee met in Bogotá in October, 1971, to analyze the experience gained from the first studies and plan for the ones to follow. In particular, the committee agreed to unite three formerly separate studies into one on engineering, applied geology, and physics. Because, of the three, engineering has reached the highest level of development in Colombia and is the field for which there is the most urgent need, it was selected for major emphasis. COLCIENCIAS then selected six priority fields for examination by working groups:

1. Chemical engineering
2. Applied geology and metallurgical engineering
3. Civil engineering
4. Physics and electrical engineering
5. Mechanical engineering
6. Systems and industrial engineering

On February 14, 1972, the 11 members of the U.S. panel met with the Colombian panel in Bogotá for a day-long discussion on the current status and recent trends in Colombian higher education. During the next 5 days, working groups visited 34 departments in 8 universities selected by COLCIENCIAS and ICFES.

The second week began with a day-long plenary session for review of the experiences and observations of each of the six working groups and for

discussions with representatives of industry and professional societies. During the next 3 days, the working groups analyzed their findings and drew up reports of their evaluations and recommendations. The six detailed working-group reports, containing basic information about the 34 departments visited, references to their most pressing needs, and suggestions for their continued development will be issued in Spanish by COLCIENCIAS. The important considerations and policy issues common to most, or all, of the working-group reports are the subject of this report, which is based on the Spanish report but does not literally follow its outline or organization.

Before arriving in Bogotá, each NAS panel member was furnished with background material about some of the universities and the Colombian system of higher education generally. These documents were helpful for orientation.

In general, the panel achieved, in its working-group reports, a series of constructive recommendations for strengthening each discipline or department. The panel also estimated the potential of each department to establish and support an M.S. program in one of the six fields over the next 5 years. (See Appendix Table.) Unfortunately, limits of time, available information, and the terms of reference of the study prevented the U.S. panelists from making more detailed analyses of such factors as staff and research quality in individual departments, costs of strengthening departments, or available manpower--all essential for a complete evaluation.

The biology study, last of the series, took place May 29 - June 13, 1972. To interrelate the conclusions of the various studies and to map

out a strategy for phased implementation of the findings, a meeting of the executive committee is planned for October, 1972, with the participation of a small number of study members from both countries.

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THE NEED FOR GRADUATE EDUCATION IN ENGINEERING, PHYSICS, AND APPLIED GEOLOGY

Available quantitative data are not very useful in estimating the future demand for graduate courses or master's degrees in Colombia. Existing data show an underutilization of the skills of M.S. level engineers, physicists, and geologists in industry; and some schools report difficulties in finding jobs for their trained graduates. This situation is reflected in a lack of incentive for higher training and reflects a lack of appreciation for, or confidence in, productivity from research. However, past practice of industrial and other hiring organizations may not offer useful guides to future demand. Significant changes in industrial structure, scale, and sophistication are anticipated as Colombia's rapid development continues.

Although there are no quantitative indicators to justify large crash programs in graduate education in engineering, physics, and applied geology, there are several arguments in favor of selective development of individual graduate courses and selected M.S. programs:

1. In some fields (such as systems engineering) there is a present, identifiable need for personnel with advanced degrees, and these disciplines often depend on simultaneous advanced work in related fields. Information gathered informally suggests varying needs for each discipline and its associated graduate work. Moreover, most training in these fields is now available only in other countries and may not be oriented to Colombian requirements.

2. Engineers and scientists in all disciplines need to refresh and upgrade their skills constantly. This need can often be satisfied through short continuing-education courses, preferably sponsored jointly with industry or user groups. Some of the faculty for these courses can come from other countries, but for maximum flexibility in courses and impact on the society, most of the faculty should have deep knowledge of the specific Colombian situation.

3. For undergraduate programs to remain up-to-date, sufficient graduate teaching, training, and research opportunities must be available so that faculties keep themselves informed of advances in their fields. Otherwise, even well-trained faculties can rapidly become obsolete.

4. Colombia's vast latent resources and increasingly more technologically advanced industries will demand highly trained nationals. Sophisticated geological knowledge is needed to identify mineral resources and see to their rational development. Highly trained personnel will be needed to evaluate and adapt technologies from abroad and to solve new technical problems unique to the Colombian culture. Without trained nationals, Colombia will always be dependent on outside technological help in finding solutions to these problems.

5. Availability of graduate engineers, physicists, and applied geologists will, possibly in the short term and certainly in the long term, generate a demand for their use, as it often has in other countries--if their training is of high quality, relevant to the local situation, and suitable for application. To meet this need for graduate education, it is not necessary to establish many complete M.S. degree programs immediately. In some cases, universities can start individual short courses or specific

academic courses that are not directly related to a degree program. There are many opportunities to develop such graduate work at low initial costs. Later, as resources, research, and related courses develop at a university, they can perhaps be molded into degree programs.

6. It is often possible to schedule work for advanced degrees according to national urgencies. For example, geologists are needed before extractive metallurgists, who, in turn, are needed before mining engineers; and each previous discipline can contribute to advanced work in its successor's field.

Within the next decade, advanced engineering work will be needed in many fields. Selective support of graduate engineering courses and a few priority programs seems a logical present step in the continuing expansion of Colombian technical education. At first, only one or two master's programs should be supported in each discipline. Care must be taken not to expand their number too rapidly, lest quality be disastrously affected. Although this joint study places heavy emphasis on the importance of high-quality graduate programs, it wishes to point out the danger of inhibiting their development by setting excessively high requirements.

The Appendix table lists the departments that will probably be able to develop M.S. degree work of high quality in the near future in engineering, physics, or applied geology. It also estimates the time each will probably require to develop the programs, if the universities and departments soon follow the suggestions of the panel. More rapid or delayed actions would of course affect this schedule significantly.

II

THE NEED FOR UNIVERSITY RESEARCH

Increased research at universities will be essential to economic, educational, and social advances; therefore, support should go to research that both improves education and solves specific problems associated with Colombian development.

1. Research can teach engineers, physicists, and applied geologists an essential skill--how to attack real problems. Through such research engineers will acquire confidence and attitude needed to attack important industrial, governmental, and social problems that can be solved only by Colombians working on uniquely Colombian problems. Active participation is also necessary to teach students research methodology and scientific objectivity.

2. Research is essential to keep well-trained faculty from stagnating after receiving their degrees. Systematic pursuit of new knowledge, and application of knowledge to new problems, keeps faculty at the frontier of their disciplines and ensures that the most modern concepts can be taught in the classroom. Continuing research is especially important when a large portion of faculty has been trained outside the country and is teaching primarily at the undergraduate level.

3. Unlike industrial or institute research, university research is immediately transferred to students who apply it in a wide variety of fields. Most university research can also be published in a way that adds

to the body of knowledge available to all and prevents duplicate efforts in Colombia and in other countries with similar problems. Furthermore, publication brings prestige to the university and the country.

4. To draw up rational research proposals for international funding and to evaluate proposals of others, research experience is needed. It can be especially important to the evaluation of large, new technological projects, whether proposed internally or externally.

The group feels that the primary need in graduate education is for applied research. In other countries such research has repeatedly proved to be valuable training experience for students. Applied research teaches research methodology and gives students experience in solving real problems. Although the day-to-day problems of industry should, of course, be avoided, many challenging industrial, governmental, and institutional projects are appropriate for study.

Of course, some basic research in selected fields is desirable. For example, basic research on Colombian geological structures or natural resources could serve later as a basis for solving many practical problems. But the primary need in engineering, geology, and physics is for well-conceived, applied research projects, supported by rewards for research in the universities and external support from government, industry, and other user groups.

III

CONSTRAINTS ON DEVELOPING GRADUATE EDUCATION AND RESEARCH

The panel identified several important constraints on developing graduate courses and research in engineering, physics, and applied geology. The working-group report discusses the effects of these constraints on each discipline. The most serious constraints and suggestions for their possible removal are summarized in the following:

1. Inadequate Development and Retention of Faculty. The most serious constraints to developing graduate education and research in the universities are the small number of highly qualified faculty and their high rate of turn-over. Colombia must be commended for its efforts in developing full-time faculty and its extensive programs for educating faculty abroad. Vast improvements in faculty quality have been achieved in the last 10 years, but further advances are still needed, particularly ending the tradition of hiring the school's own graduates as professors. Some of the most important needs for faculty development and retention follow:

- a. Increased opportunities and resources for faculty research;
- b. Increased opportunities for continuous faculty training through sabbaticals and advanced courses;
- c. Increased interaction with other faculties.

2. Inadequate Reward Systems. At the heart of the faculty problem is the existing reward system. Levels of compensation within the university are determined largely by seniority and, in some cases, by advanced

degrees. None of the reports furnished by the universities mentioned special rewards for productivity in research or publication. The panel recommends that in establishing the university reward systems the following be considered:

a. Salary levels for highly trained faculty should more closely approximate industrial levels. Because industry commonly pays 50 to 100 percent more than universities pay for engineers and scientists with the same background, good faculty members are often tempted to leave the university.

b. Special merit systems--such as more rapid advancement or salary differentials--should be devised within professorial ranks to reward outstanding teaching, research, publication, university administration, and other professional activities. Care should be taken, however, to assure that all aspects of a professor's responsibility receives due consideration.

c. Special nonfinancial awards and prizes could be instituted for outstanding performance; for example, titles (like Fellow) or prizes might be offered by universities or national groups.

3. Lack of Student Research. One of the most important problems in the development of graduate programs is the lack of opportunity for student research. As a result, students complete their studies without the experience necessary for initiating their own research and carrying it through to completion. This problem is partly attributable to the fact that many are part-time students. One step taken to alleviate this situation is the awarding of scholarships by the Colombian Institute for Educational Loans and Technical Studies Abroad (ICETEX) to outstanding students. The joint

study panel strongly recommends that funds for student support be increased considerably.

4. Lack of Equipment for Teaching and Research. The quantity and quality of research, laboratory, and teaching equipment (instruments, machinery, testing machines, computers) is usually a severe constraint on graduate schools of engineering and sciences. The panel encountered several common problems:

- a. Important equipment cannot be obtained by any means.
- b. Installed equipment is of no use because it is not adequately maintained.
- c. Equipment is available somewhere in Colombia, or even in the same city, but is not accessible to the faculty and students of a particular department.
- d. Workshop facilities for constructing and modifying mechanical and electrical equipment are not available.

Without committing Colombia to acquiring large amounts of scientific equipment, the panel recommends several policies to improve the situation:

- a. Various departments in a metropolitan area should arrange for cooperative use of their equipment. Universities in Medellín are already doing this with the computer at the National University.
- b. Import tariffs for teaching and research equipment should be reduced.
- c. Research facilities should be concentrated in a few centers to avoid dispersion and duplication of costly equipment.
- d. COLCIENCIAS should award grants for research professors to travel to use special equipment.

e. Universities should make better use of programs like Tools for Freedom, by which surplus equipment from other countries is imported at low cost.

5. Insufficient Library Holdings. The quality of graduate education and research is closely related to the quality of the library. It is therefore extremely disturbing to find an insufficient number of books and, above all, specialized journals in the university libraries. In some cases, the personal library of a professor is larger than the specialized section of the university library. Also, there is a lack of the data and statistics that are essential to particular research. Therefore, the joint study panel suggests the following ways to improve library facilities:

a. Subscribing to numerous journals distributed without charge by research centers, universities, and other institutions;

b. Urging the Colombian government to help libraries import books and specialized journals by simplifying red tape and reducing postal rates on such items;

c. Accelerating the establishment of a national information system; and

d. Expanding the holdings of books and technical journals from other Latin American countries, particularly in areas related to natural resources such as geology.

6. Lack of Suitable Research Publications. A policy to encourage the development of scientific and technical publications could bring national and international prestige and influence to authors and their institutions, reduce duplication of effort, and promote stronger communication among Latin American researchers. Many Colombian professors are

not convinced of the importance of publication, and many of their papers are printed in university bulletins with very limited distribution. The panel recommends:

- a. That university collections of scientific and technical journals be consolidated and then distributed widely to universities, consultants, and public and private organizations;
- b. That national and international agencies cooperate to develop Latin American journals of applied research of particular importance to Latin America;
- c. That faculty be encouraged to participate in the activities of professional societies and to publish their work in recognized journals; and
- d. That possibilities for reducing dues to U.S. professional societies from developing-country members be explored.

7. Insufficient Communication between Engineering and Supporting Departments. The engineering programs reviewed by the panel have basic prerequisite courses in physics, chemistry, mathematics, economics, and management; but in many universities there is not enough communication between engineering professors and supporting departments. Therefore, the panel recommends the organization of informal faculty-student liaison committees which would promote close working relationships and coordination of teaching and research activities.

8. Weak Connections between Universities and User Groups. Improved ties with industrial and other user groups are essential to the future progress of graduate education and research. Because research by faculty

and students needs to be oriented toward practical problems, faculties need increased contacts with the public they serve. User groups--especially those in industry--need better knowledge of university capabilities. A number of possible ways to improve university - user relations are suggested:

a. To increase use of faculty research by government, institutions, and industry, COLCIENCIAS might provide partial support to user groups that conduct projects with or in the universities.

b. The formation of work groups with participation from universities, government institutions, and industry to define and work on specific problem areas--sanitation, pollution, water resources, or urban planning, etc.--would help to establish priorities and develop specific courses of action. Moreover, these groups could publish reports and suggest sharply focussed problems to consultants and universities. Perhaps the professional societies could provide leadership in creating these work groups.

c. Relations with industry offer special opportunities. Industry could support short courses at universities, focussing on its special needs and interests, perhaps offering extra compensation to faculty for teaching these courses. Industry and universities could jointly develop recruitment and placement programs to match students to job opportunities. In addition to sponsoring research on its problems, industry might help professors understand its problems by providing summer or sabbatical positions for faculty or allowing its trained people to take 1-year, full-time appointments in universities. In general, the panel commends industry's present willingness to allow its trained people to teach part-time in universities. We hope industry will go further in providing interesting projects for student and, perhaps, in supporting faculty research.

d. The panel urges the universities to consider greater latitude in their consulting policies. Faculty consulting can offer many benefits to the university, such as firsthand knowledge about governmental or industrial problems, identification of useful problems for student projects, and opportunities for faculty research. As with industrial sponsorship of university research, consulting activities can provide supplements to faculty salaries, often a critical need, in view of university pay-scales.

The panel is aware of the conflicts between graduate schools and private consultant firms caused by university participation in applied research, the principal occupation of consultant firms. Mutually beneficial arrangements have been successful in other countries but seem to be difficult in Colombia because both groups appear to be competing for the same funds and projects. Yet, faculty and students must have the stimulation provided by work on real problems, and consultants need the fresh, analytical viewpoint offered by interaction with the university faculty. When answers must be provided quickly and depend upon previous experience, the experience and judgment of a private consultant are invaluable. When fundamental knowledge already exists, consultants can apply and refine it with new techniques. However, in interdisciplinary, conceptual, or feasibility studies of a new problem, the unique and broad resources of the university cannot be duplicated by most consultants. The panel thinks that prohibiting university professors from accepting consultantships with industry will stifle the research creativity of faculties and students and eventually affect Colombian development adversely. To avoid excessive competition, faculty should charge fees comparable to those of private consultants and include in the charges all overhead costs (i.e., for the use of university services of facilities).

9. The Restricted Role of Professional Societies. The joint panel knows of the existence of several professional societies in Colombia, but time for direct contact with the societies was very limited. The panel received a general impression, which was corroborated by many Colombians, that the societies are not exploited to full advantage in the development of graduate education and research. Their journals could take on the larger role of primary research publications. (A fuller discussion of the need for research publications was presented in III.6.)

A full and balanced membership in professional societies with representatives from government, universities, and industry would greatly strengthen communication and stimulate common understanding of each sector's problems (see also III.8.). Moreover, each sector would have access to an open forum for discussions of technical questions and public policy issues. A recommendation for the full participation of university professors in professional societies was made in III.6.c. The importance of this point must be emphasized. Through these societies valuable associations would be established between scientists and policy makers so that new ideas could be subjected to critical and searching analysis.

10. Limited Demand for Advanced Degrees. Government policies can do much to stimulate the demand for holders of advanced engineering degrees. Government departments and institutes could be encouraged or required to hire a significant percentage of engineers and scientists with advanced degrees. Incentives could be offered to domestic and multi-national industry to perform research in Colombia, by, for example, allowing profit repatriation and overhead charges from parent companies to be adjusted according to

R & D performed in the country or requiring industrial contributions to joint industry - government sponsored research institutes.

University policy could require that some percentage of faculty have advanced degrees for programs to be certified.

In the first years of graduate programs, any or all of these incentives may be needed to stimulate growth of graduate courses and programs.

IV

AGENDA AND PARTICIPANTS

AGENDA

February 14, 1972

- Morning Opening Session
- Introduction of the Joint Panel to the Executive Committee of the sponsoring agencies and Special Guests
- Summary of the program for the joint study, Hector Prada, COLCIENCIAS
- Presentation of the Educational Development Plan, Guillermo Mojica, National Department of Planning
- Presentation of the Plans in Higher Education, Daniel Ceballos, ICETES
- Presentation of Research Programs, Alberto Ospina T., COLCIENCIAS
- Discussion
- Afternoon Administrative Session, detailed plans and objectives

February 15 - 20, 1972

Visits by the six joint working groups to university departments

February 21, 1972

- Morning Roundtable discussion by panel members
- Afternoon Open session with spokesmen for Colombian industry and professional societies

February 22 - 24, 1972

Working group sessions

February 25, 1972

- Morning Closing session, Presentation of the General Report to the Executive Committee and invited guests

LIST OF PARTICIPANTS

Colombian Participants

Hector Prada, General Coordinator
Head, Department of Industrial Engineering
University of the Andes
Bogotá

Eduardo Aldana
Vice President
University of the Andes
Bogotá

Jorge Ricardo Bernal
Director and Professor
Graduate Program in Chemical Engineering
National University
Bogotá

Alvaro Coral
Professional Consultant
Colombia

Ernesto Corredor
Geologist
Institute of Geology and Mining
Bogotá

Raul Gomez,
Professor, Department of Mechanical
Engineering
Executive Secretary, Graduate Committee
School of Engineering
University of the Andes
Bogotá

Arturo Infante
Executive Director
National Fund for Development
Projects
National Department of Planning
Bogotá

Alfredo Leon
Executive Director
Colombian Institute of
Administration
Call Division

Roric Plasas
Manager
Plasas and Company, Ltd.
Bogotá

Ricardo Picon
Director
Institute of Testing and
Research
School of Engineering
National University
Bogotá

Eduardo Silva
Head, Metrology Center
National Service of Norms,
Metrology, and Quality Control
Bogotá

COLCIENCIAS Staff, Bogotá

Eduardo Arias, Director
Division of Human Resources

Jaime Ayala R.
Scientific Director

Alvaro Franco F.
Office of International Relations

Guillermo Franco, Director
Division of Economic Affairs

Ignacio Valero
Division of Human Resources

Alvaro Velasquez
Division of Studies on Scientific
and Technological Infrastructure

U.S. Participants

William L. Everitt, Chairman, U.S. Panel
Dean Emeritus, College of Engineering
University of Illinois
Urbana, Illinois

James Brian Quinn, Coordinator, U.S. Panel
Amos Tuck School of Business Administration
Dartmouth College
Hanover, New Hampshire

Richard L. Anderson
Department of Electrical Engineering
Syracuse University
Syracuse, New York

Camden A. Coberly
Associate Dean
College of Engineering
University of Wisconsin
Madison, Wisconsin

Victor W. Goldschmidt
School of Mechanical Engineering
Purdue University
Lafayette, Indiana

Hugh D. Guthrie
Chemical Engineer
Shell Oil Company
Houston, Texas

Alfred C. Ingersoll
Associate Dean
School of Engineering
University of California
Los Angeles, California

Carl M. Irving
U.S. Geological Survey
U.S. Agency for International
Development
Bogota, Colombia

James E. Lawver, Director
Mineral Resource Research
Center
University of Minnesota
Minneapolis, Minnesota

Ulrich Aeteren
Department of Geological
Sciences
Harvard University
Cambridge, Massachusetts

Gerald L. Park
College of Engineering
Michigan State University
East Lansing, Michigan

NAS Staff

Cecilia Allman
Administrative Assistant, BOSTID
Office of the Foreign Secretary
National Academy of Sciences
Washington, D.C.

James G. Zavistoski
Professional Associate, BOSTID
Office of the Foreign Secretary
National Academy of Sciences
Washington, D.C.

Executive Committee

Camilo Cárdenas
Head, Division of Technical Assistance
National Department of Planning
Bogotá, Colombia

Daniel Ceballos
Director, Colombian Institute
for the Development of
Higher Education
Bogotá, Colombia

Guillermo Mojica
Head, Division of Human Resources
National Department of Planning
Bogotá, Colombia

Alberto Ospina T., Director
Colombian Fund for Scientific Research
and Special Projects
Bogotá, Colombia

James G. Zavistoski
(Representative for Harrison
Brown, Foreign Secretary)
National Academy of Sciences
Washington, D.C.

HIGHLIGHTS AND COMMENTS

Pre-Study Preparations

Preparations for this study drew heavily upon the experiences of earlier studies in chemistry and mathematics. Because of the heavy demands on its staff experienced previously, COLCIENCIAS decided to hire a temporary consultant for this study. Very able and conscientious, the consultant traveled at least once to every university to be visited by panel members to inform and orient responsible officials. His selection of Colombian participants to travel with the NAS panel was excellent. However, COLCIENCIAS gathered little background information specific to engineering, physics, and applied geology in the universities or in Colombia as a whole. To brief its panel, the NAS depended on other sources, such as the U.S. Government, the Inter-American Development Bank, the Organization of American States, the United Nations, and current journals.

Study Participation

At the opening session of the 2-week study, representatives of the three Colombian co-sponsoring agencies--COLCIENCIAS, ICFES, and the National Department of Planning--gave summaries of their agencies' major activities. A particularly informative discussion ensued with a Department of Planning official about the proposed education reform law. Unfortunately, after the opening session, the participation of ICFES and the Department of Planning was minimal.

The university visits were quite successful. Local university officials were very hospitable: They received the joint groups at the airport, provided transportation, arranged hotel reservations, and, when possible, hosted lunches or dinners. More importantly, however, talks by high-level officials were extremely effective in presenting the overall goals of the university so that the panel's concerns might be put in perspective. Most faculty members were equally polite and were prepared with information on the substantive issues of concern to the panel. Only a small number of the 34 departments had made little or no preparation for visits to their laboratories and with their faculty.

Without exception, the six working groups asked to visit additional universities or industrial sites, voluntarily adding to their already busy schedules by using either brief periods of free time during the week or, more often, working on Saturday. On short notice, COLCIENCIAS and the universities made every effort to arrange these visits.

The first week's activities met or surpassed all objectives and were capped by a delightful afternoon on the farm of one of the Colombian participants, offering an opportunity for more informal exchange of ideas among participants.

In the second week, analysis of the information gathered during the visits began with an informal round table discussion at COLCIENCIAS. Members of the six panels shared their observations and agreed on objectives for the subsequent working-group sessions. Unfortunately, the afternoon plenary session in the auditorium of the Colombian Society of Engineers with representatives of industry and the professional societies was inadequately organized and poorly attended. Bringing together academic and industrial

scientists to discuss common needs and opportunities for cooperation is difficult in many countries, but, apparently, little initiative was taken to compensate for this, even though the difficulty was anticipated and discussed in the planning stages of the workshop. The problem was further compounded by the choice of a large auditorium for an audience of only about 50 people, and the impromptu decision to eliminate from the agenda the planned 10-minute presentations by five or more representatives of industry. The result was that the free exchange of ideas essential to the full success of this exercise was not possible.

It was agreed previously that each working group was to include six to eight Colombians from the sponsoring agencies, industry, and the universities, but for logistic and financial reasons, only one or two Colombians could participate in the university visits. It was understood that the larger representation would participate in the second week. Regretably, this was not the case. Fortunately, a cocktail reception at the home of the AID Human Resources Officer made possible some additional input from Colombians representing the various sectors of the engineering community not represented on the panel.

Working-group sessions focussed on analysis of problems and formulation of suggestions, recommendations, and conclusions.

Colombian participants were completely dedicated to the work of the study, and it was largely through the efforts of the Colombian participants that the six working-group reports and the "General Report" were translated into Spanish. Even though their usual official responsibilities were pressing and their offices nearby, most of them remained at the sessions throughout the week.

Just 2 days before the closing session, attendance at the sessions was quickly changed from a fully open to a more limited one. The Colombians feared that the discussions might stimulate adverse reactions, particularly among students, by appearing to conflict with the trend toward decentralization of university planning. Even if one allows for these concerns and precautions, however, attendance at the closing session was disappointing. Except for two or three people, only the panel members were present. There was no press coverage given to the study.

Facilities

Most of the study sessions took place at COLCIENCIAS. The principal meeting room was rather small, permitting a degree of informality and free discussion that was impossible in the crowded auditorium of the Colombian Society of Engineers. The facilities for the working group sessions, in three locations, were adequate.

Before the panel convened, there was concern about the lack of provision of simultaneous translation. Fortunately, however, most Colombian participants spoke some English. Language difficulties were evident during the important plenary session with representatives from Colombian industry and professional societies.

Secretarial services were scarcely adequate to produce the "General Report" and the six lengthy working-group reports. Recognizing the problem, COLCIENCIAS brought in a temporary secretary. Even so, the burden on those responsible for typing and mimeographing was excessive.

Initial Follow-up Activity

As noted earlier, this study is part of a series, and overall priorities for programs in graduate education and research in Colombian universities

must await the report of the study in biology. A meeting of the executive committee is planned for October, 1972, to bring together the results of the several studies and lay the groundwork for implementation. In the meantime, COLCIENCIAS will act, where possible, upon specific recommendations. At the closing session, the U.S. panel strongly recommended that the full report be circulated among all university departments visited, to serve not only as a critical guide to program development but also as a much-needed communication link among the departments.

Concluding Note

Interest in the role of science and technology in economic development is recent in Colombia and is not shared equally among all agencies of the government. COLCIENCIAS was established about 4 years ago and is still experiencing difficulties in asserting itself. About any policy decision COLCIENCIAS makes, or program on which it embarks, is viewed by some existing governmental agency as an infringement on its prerogatives. Unfortunately, it is in this suspicious, even hostile, environment that COLCIENCIAS must survive and grow.

Since the present studies began in March, 1970, there have been changes in the Colombian situation that have had a pronounced effect on the program's execution. As mentioned earlier, a philosophy of decentralizing educational decision-making has caught national attention. Student agitation has greatly increased. Governmental agencies other than COLCIENCIAS are vying for power to make policy decisions on science and technology. Therefore, it is not at all surprising that COLCIENCIAS has acted most cautiously throughout this

study. COLCIENCIAS' decisions, and the relative strengths and the weaknesses of the study, must be considered within the context of the total Colombian situation.

APPENDIX

Estimated Time Needed To Develop High-Quality Master's Programs in
Colombian Universities, by Discipline^a

Discipline	1 Year	2 - 3 Years	4 - 5 Years
CHEMICAL ENGINEERING	UIS ^b	Valle	Antioquia
INDUSTRIAL & SYSTEMS ENGINEERING	Andes	Valle National (Bogotá)	Medellín National (Medellín)
MECHANICAL ENGINEERING ^c			
ELECTRICAL ENGINEERING		Andes	Cauca Valle UIS National (Bogotá)
GEOLOGY		National (Bogotá)	
MINING & METALLURGY			Medellín
METALLURGY	UIS		
PHYSICS	National (Bogotá)	Valle UIS	
CIVIL ENGINEERING			
SANITATION	National (Bogotá) Andes		
PUBLIC HEALTH	Valle Antioquia		
STRUCTURES	National (Bogotá) Andes		
TRANSPORTATION	National (Bogotá)	Cauca	
PUBLIC SYSTEMS	Andes		

^aBased on the six working-group reports and the qualifications therein, and on the assumption that financial support will continue at the present, or somewhat higher, levels. The panel emphasizes that placement of departments is not based only on the quality of existing programs. For example, a number of departments have undergraduate programs of high quality but need several years to remove obstacles to establishing master's programs--insufficient faculty with advanced degrees, insufficient laboratory space, etc. The reader is urged to study the full report with its detailed reports on each department visited.

^bSee next page for key to abbreviations of universities.

^cSee the detailed working-group report on each department visited.

Abbreviations in Table

Andes	- University of the Andes, Bogotá
Antioquia	- University of Antioquia, Medellín
Cauca	- University of the Cauca, Popayán
Medellín	- University of Medellín, Medellín
National (Bogotá)	- National University, Bogotá Campus
National (Medellín)	- National University, Medellín Campus
UIS	- Industrial University of Santander, Bucaramanga
Valle	- University of the Valley, Cali